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A THIRD CLASS OF HIGH ENERGY BURSTER

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Until recently, only two cosmic high-energy burster classes--x-ray bursters and gamma-ray bursters (GRBs)--were recognized. However, as early as 1979 it was realized that events similar to GRBs, but which did not fit comfortably into that class, occasionally occurred. This realization arrived in the form of the famous "March 5 Event" of 1979, which had, among its many unique attributes, typical photon energies of tens of keV--that is, midway between x-ray burster and GRB energies. Subsequently, the source was seen to repeat sporadically about a dozen times, with about one day separating the closest recurrences.[1] Eventually, a few other bursters unlike normal GRBs and possibly related to the March 5 source were found. All had similar average photon energies of tens of keV, and most had durations of tenths of a second. One of them, first seen on 1979 March 24, repeated twice within three days.[2] Unfortunately, this suspected third class of high-energy burster may be one of the least well studied phenomena in astrophysics. This is largely because most of the photons are emitted at "awkward" energies, in the gap between the regions of coverage provided respectively by most of the x-ray and gamma-ray instrumentation in space.

Fortuitously, the International Cometary Explorer (ICE) spacecraft contains an experiment, built by a UC Berkeley/Los Alamos collaboration, that is reasonably well suited for the study of this type of event. However, the detector field-of-view (a 10° FWHM band centered on the ecliptic plane) always includes the same 15% of the sky, with the remaining 85% being forever inaccessible. Neither of the 1979 repeating sources was favorably located; but, an event with similar characteristics occurred on 1979 January 7 in the proper part of the sky to be observed by ICE. The results of this observation were recently published.[3]

Then, in the Spring of 1986, K. Hurley and colleagues in Toulouse, France, using data from their experiment on the Prognoz 9 (P9) satellite, informed us of possible source activity similar to that seen from the 1979 March repeaters. Specifically, in a 6-month period they observed four discrete groups of two or three short events (for a total of 9 events). Within a group, the bursts were separated by one to three days. No other information on the events was available at that time. Using our ICE data, we quickly found that four of the P9 events were located within the ICE field of view and were spectrally and temporally very similar to the 1979 January 7 burst. Thus, it appeared that the January 7 source might indeed be in the same class as the 1979 March repeaters. Further, it seemed that these objects could be dormant for long periods of time, but that they would eventually repeat as often as once per day for a few days.

At this point it occurred to us that, given the superior ICE temporal coverage and sensitivity to sources near the ecliptic plane, a systematic search through the ICE data base might turn up one or two additional source repetitions. What we actually found was completely unexpected. During a single day, 1983 November 16, a total of 18 events were detected; 10 occurred within an hour, with some separated by minutes or even seconds. During the month of November ICE recorded 63 events. A laborious search covering nearly eight years of ICE data revealed 48 additional repetitions, for a total of 111. Approximately 20 of these also were observed by other spacecraft.

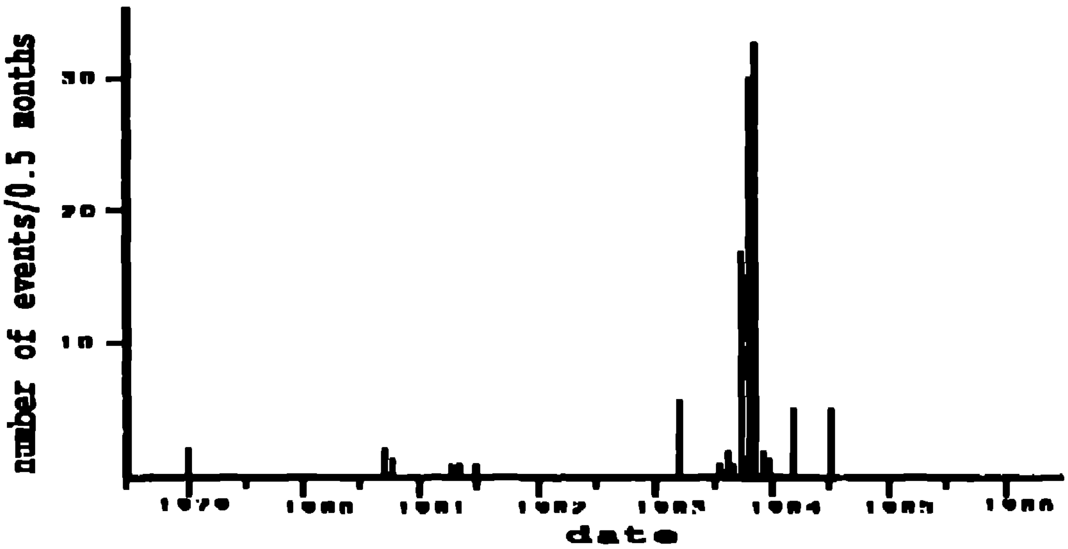

Figure. Events vs. time from August 1978 through June 1986 at 0.5 month time resolution.

Of particular importance were three detected by the Pioneer Venus Orbiter Gamma Burst Detector. These three, which could then be located accurately by interplanetary arrival-time analysis, provided the firm link between GB790107 and the 1983 November activity. The Figure, which shows number of events vs. time for eight years, at 0.5-month time resolution, summarizes our results. We had clearly discovered a new and unique kind of repetitive behavior in a high-energy burster.

The nature of the source is still being investigated. At this point we know that the repetitions are similar to one another in every respect except intensity, where a range of at least a factor of 30 is seen. The durations of the events are typically 0.1 s, plus or minus about a factor of 2. The characteristic photon energy is about 30 keV, and there is evidence for a deficiency of photons below 10 keV, relative to a simple thermal bremsstrahlung model. Perhaps the most amazing feature of the repetitions is that they can be separated by anywhere from seconds to years, and there is almost no correlation between intensity and separation. (This is in contrast to the Rapid X-ray Burster, where the intensity of a burst determines the time interval to the next burst.) No periodicities have been found. The only convincing pattern to the repetitions is their tendency to cluster, evident in the Figure. This clustering seems to persist on time scales as short as hours.

A final point is that this third class of burster is still very poorly observed. Were it not for the good luck of having the source of GB790107 constantly within the ICE field-of-view, our picture of its repetitive behavior would be entirely different. It is likely that lack of sensitivity and incomplete temporal coverage have prevented us from observing this same behavior in other sources.

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